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UBIQUITOUS SYSTEM CAPABILITIES AND USER READINESS: AN ACTIVITY PERSPECTIVE

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Abstract

Based on the basic premises of both human-computer interaction research and technology acceptance research, this study investigates the relationship between ubiquitous system design and user adoption. Using the unifying framework of Activity Theory, it conceptualizes user-system interaction as a tool-mediated activity. From this perspective, interactivity, personalization and contextualization are the basic design features that enable a ubiquitous system to facilitate such an activity in different ways. It is hypothesized that these system capabilities shape major user experiences including sense of control, perceived understanding and motive fulfilment, which lead to how ready they are to interact with the system. The empirical results obtained from an experiment support the hypothesized relationships, and suggest that the system capabilities interplay with each other in their effects. The finding provides insight on how to balance the capabilities in the design of ubiquitous systems for different tasks and different users.

Keywords: Activity Theory, Ubiquitous System Design, Interactivity, Personalization, Contextualization, User-System Interaction.

1 INTRODUCTION

The advance of information and communication technology enables ubiquitous systems for users to access information services anywhere and anytime through mobile devices such as smart phones (Poslad, 2009). Despite the huge success, the failure rate of such applications remains high, and a main reason is the insufficient incorporation of user involvement and requirement into system design (MobiThinking, 2013; Ogara & Koh, 2014). Thus, the question “what kind of ubiquitous systems would people like to use?” has been both intriguing and puzzling to researchers and practitioners.

Though the detailed implementation varies from one ubiquitous system to another, there are some common considerations, such as interactivity and personalization. These design features are related to the basic capabilities of a system that make it functional and effective: interactivity allows systems to accept user input and respond with output (Burgoon et al., 2000), and personalization let systems adapt the communication to user preferences (Thongpapanl & Ashraf, 2011). Recently, the advance of context-aware computing enables systems to utilize contextualization for catering to users’ needs in their changing environment (Dey, 2001).

The way that people use a ubiquitous system depends on the design features it offer. For example, a user does not need to indicate individual preferences every time if a system is personalized. Thus, interactivity, personalization and contextualization influence user experiences in interacting with various systems. Though they intend to enhance user experiences, actual effects are not always as expected. What developers consider a good design may turn out to be unappealing to users. For example, some contextualized systems notify users of things available nearby when they come across some “points of interest” (e.g. restaurants), and such location-based services (LBS) actually annoy many users (Rao and Minakakis, 2003). In addition, system capabilities interact with each other in their effects on user behaviour. For instance, combining contextualization and interactivity by letting users inquire rather than passively receive information makes LBS more appealing (Sun, 2003).

Previous studies have provided insights on how a single capability – interactivity (e.g. Burgoon et al., 2000), personalization (e.g. Thongpapanl & Ashraf, 2011) or contextualization (e.g. Barkhuus and Dey, 2003) – may affect user experiences. The implementation of a ubiquitous system, however, usually endows it with multiple capabilities. It is important to study the effects of different capabilities in a systematic way because of the possible interplays among them. One challenge to examine interactivity, personalization and contextualization together is their stand-alone definitions (c.f. McMillan and Hwang, 2002; Greenberg, 2001; Riechen, 2000). It is necessary to examine their different roles in facilitating user-system interaction and define them in relation to one another.

Based on the premise of Activity Theory, this study will adopt two streams of research, human-computer interaction and user acceptance of technology, to understand the roles that interactivity, personalization and contextualization play in user behaviour. Such an investigation may help address the problem of definitional multiplicity among system capabilities, as well as their interactions with each other. The purpose is to answer the ultimate research question of how the variation of these system capabilities in design influences user adoption of different ubiquitous systems.

2 THEORETICAL BACKGROUND

Human-computer interaction (HCI) research deals with “the design, implementation and evaluation of interactive systems in the context of the user’s task and work” (Dix et al., 1998, p.3). Existing studies of user behaviour in this stream examine certain user experiences in interacting with various systems, such as interaction involvement (Burgoon et al., 2000). The understanding provides insight on how to improve the implementation of systems, especially interface design (Shneiderman, 1998). Due to the main focus on design, few HCI studies move on to address the question of how these experiences shape people’s attitude towards using the systems. It is such an attitude – formed on the basis of user experiences with a system – that connects the previous use and future use of the system at the individual level (Jasperson, Carter and Zmud, 2005). Technology acceptance research in the information systems (IS) field, on the other hand, focuses on user attitude to address how likely an individual is to use a certain system but did not include system design into analysis (c.f. Venkatesh et al., 2003). Based on the notion that HCI research and IS research can shed light on each other for a better understanding of user behaviour (Zhang et al., 2002), this study investigates how system capabilities including interactivity, personalization and contextualization affect user attitude.

Rooted in social psychological theories such as Theory of Reasoned Action (Fishbein and Ajzen, 1975), technology acceptance theories examine user behaviour in the unit of an action between a subject user and an object system. The behavioural outcome – intention to use a system – depends mostly on the cognitive evaluations of it, such as perceived usefulness and perceived ease-of-use in the well-known Technology Acceptance Model (Davis, 1989). Such evaluative perceptions hardly reflect specific experiences that users have in interacting with a system to capture the effects of particular system capabilities on the continuous use of the system. Thus, researchers called for a paradigmatic shift in the theoretical perspective of system artefacts and user behaviour (Bagozzi, 2007).

This study adopts Activity Theory, a theoretical framework introduced to the HCI field in 1990s (Bødker, 1991), to study the relationships between ubiquitous system capabilities and user attitude. Such relationships are likely to be indirect: interactivity, personalization and contextualization shape user experiences in interacting with a system, which then lead to the formation of user attitude. Traditionally, HCI research focuses on the relationship between designs and experience, and technology acceptance research focuses on the relationship between experience and attitude. In an effort to reach a better understanding of how system capabilities influence user behaviour, this study adopts the premises and principles from both research streams with a unifying activity perspective.

Activity Theory was initially developed by the Russian psychologist Vygotsky in the 1920's and was later elaborated by his followers, especially Leont'ev (cf. Kuutti, 1996). Unlike most social psychological theories that take the singular human action as the unit of analysis, Activity Theory views human behaviour as an evolving system of mediated relationships among subjects, objects and tools (Leont'ev, 1978). The unit of analysis is an activity comprising a series of actions – something a subject is conscious of doing with an immediate goal – that are organized by the common motive to transform an object into an outcome with the help of all kinds of tools (Vygotsky, 1978, 1981).

According to Activity Theory, information systems are tools that people use to accomplish certain tasks (Christiansen, 1996). The object that a user transforms is not a system but the digitalized data it retrieves, processes and stores. Through the interaction with a system, a person wants to obtain the information pertinent to the task at hand (Cane & McCarthy, 2009). Thus, the motive for an individual to use a system is to transform raw data into meaningful information for a certain purpose. This motive defines the behavioural settings of user-system interaction, which can be called task context. Figure 1 depicts the relationships in such a tool-mediated and context-embedded activity.

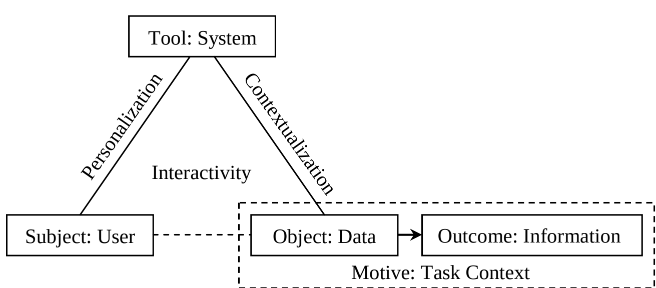


Figure 1. User-System Interaction and System Capabilities

There is an indirect relationship between *user* and *data* through the mediation of *system*. An individual cannot work on digitalized data without an information system, which is not a simple tool but a complex of software and hardware components. Compared with the action-based conceptualization, the activity perspective of user-system interaction examines user behaviour in terms of the actions associated with relevant artefacts. To understand how interactivity, personalization and contextualization shape user experiences, therefore, it is important to identify their roles in facilitating different actions in user-system interaction.

Interactivity deals with how a system allows users to specify input and receive output. Abowd and Beale's (1991) interaction framework shows that the input and output interfaces mediate the two-way communication between user and system. Based on Activity Theory, Bødker (1991) further indicates that users have access to computer interfaces for the control of data processing. Thus, interactivity is the system capability that bridge user-data gap through user-system and system-data relationships. Thus it is the fundamental capability at the center of user-system-data triangle.

Personalization deals with how a system caters to user preferences regarding the ways of specifying input and receiving output. It is the communication rules – norms, procedures and customs regarding how to exchange information – that regulate such a two-way communication (Cushman & Pearce, 1977). A personalized system allows the customization of communication rules rather than making them the same for all users. Take the above-mentioned ubiquitous application to search for local points of interest for example, a personalized system may display results based on user preferences (e.g. distance, price). Thus, personalization is a capability that directly affects user-system relationship.

Contextualization deals with how a system collects and utilizes contextual data to facilitate task undertaking for individual users. For example, a ubiquitous application may detect where users are to narrow down the search results of local points of interest. Thus, contextualization is the capability for a system to adapt data processing to real-time task context with the help of sensor technologies. A contextualized system does not just passively do what the users command, but actively engage in data processing to help people get meaningful information for the task at hand. In contrast to personalization, contextualization directly affects system-data relationship.

In summary, interactivity is the fundamental capability related to the implementation of computer interfaces that mediate user-data relationship. Personalization is a supplementary capability related to the customization of communication rules that enrich user-system relationship (i.e. from uniform to diversified). Contextualization is also a supplementary capability related to the employment of sensor technologies that extend system-data relationship (i.e. from passive to active).

3 RESEARCH MODEL

Interactivity, personalization and contextualization shape system experiences in different ways, as hypothesized in Figure 2. The latent variable user readiness reflected by input willingness (IW), output receptivity (OR) and rule observance (RO) is the predictor of system choice as the behavioural consequence. Such a user attitude is shaped by relevant user experiences in interacting with a system, mainly sense of control, motive fulfilment and perceived understanding (Sun, 2012). Among the three system capabilities, interactivity has the primary effect, and personalization and contextualization have the secondary effects on user readiness through the mediation of system experiences.

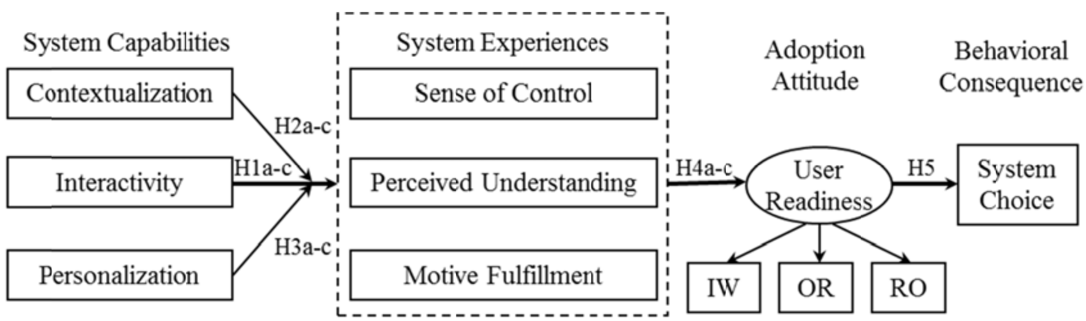


Figure 2. Research Model

Interactivity concerns user control, two-way communication and synchronicity (Guedj et al., 1980). Whereas two-way communication and synchronicity are the underlying requirements of this capability, user control is particularly related to one's experience in communicative behavior (Brenders, 1987). Personalization, based on the premise that the coordination of perspectives in a dialogue contributes to mutual understanding (Foppa, 1995; Krauss et al., 1995), may let users feel that a system is able to understand them. Contextualization requires a system to adapt information processing to the task context of each user. Because such a context defines the motive of user behaviour (Nardi, 1997; Suchman, 1987; Yaverbaum, 1988), contextualization is likely to help fulfil the objective.

Thus sense of control, perceived understanding and motive fulfilment are the system experiences closely associated with the system capabilities of interactivity, personalization and contextualization. Such experiences in interacting with systems of different capabilities lead to the formation of their attitudes toward using the same or similar systems later. The psychological construct used as the dependent variable in this study – information system interaction readiness (ISIR, simply "user readiness") – describes how prepared and willing an individual is to interact with a system for a task (Sun and Poole, 2010). The term "readiness" carries a developmental connotation because such a user attitude is shaped by previous experiences and influences future behaviour in comparable contexts.

User readiness reflects the dispositions for an array of mediated actions involved in user-system interaction, including entering user input, receiving computer output and following communication rules. The external activity shapes the internal activity that shapes the attitude in terms of cognitive beliefs, affective feelings and behavioural intentions toward taking each mediated action. Accordingly, there are three factors of user readiness: input willingness, output receptivity and rule observance.

Interactivity directly affects how users interact with a system. A non-interactive system may just display all relevant records, but an interactive system allows people specify needs through user interfaces. Correspondingly, a ubiquitous system may simply list all local points of interest and leave the user to scroll through it, or allow users to narrow down the search with certain keywords.

Whereas interactivity directly facilitates user-system interaction, personalization and contextualization enrich the process. A personalized system tailors communication rules to user preferences, and a contextualized system adapts data processing to task contexts. Thus, there are two separate but related research questions regarding the effects of system capabilities on user behaviour: 1) how different levels of interactivity make differences in user readiness; and 2) for an interactive system, how different levels of personalization and contextualization further influence user readiness? The first question concerns the necessity of interactivity to the formation of user readiness, and the second question concerns the sufficiency of personalization and contextualization to its enhancement.

As for interactivity, it should positively affect sense of control by allowing users to specify information requirements. If a system gives timely and reasonable responses, users are likely to get what they ask for and feel that the system understands them. Therefore, interactivity should also have positive effects on motive fulfilment and perceived understanding. This leads to the hypotheses below:

H1a: Interactivity has a positive effect on sense of control
H1b: Interactivity has a positive effect on motive fulfilment
H1c: Interactivity has a positive effect on perceived understanding.

Compared with interactivity, contextualization affects system-data relationship by allowing a system to collect and utilize contextual data. For some location-based services that push information to users, this capability deprives users of control because it is the system rather than the user that makes the judgment on the relevancy of information. However, if a system allows users to specify their needs, such as in the case of information requirement elicitation (Sun, 2003), users may feel in control of the interaction process as well as their situations. In an empirical study of how context-aware computing influences user behaviour, Barkhuus and Dey (2003) found that non-interactive applications weakened users' sense of control, but interactive ones did not. Therefore, contextualization is likely to enhance sense of control when the system is interactive. Because the information needs of users depend on their task contexts, an interactive system of higher-level contextualization should give more pertinent results. This not only facilitates task accomplishment, but also displays an understanding of user situations. For an interactive system, therefore, the above discussion suggests the following:

H2a: Contextualization has a positive effect on sense of control.
H2b: Contextualization has a positive effect on motive fulfilment.
H2c: Contextualization has a positive effect on perceived understanding.

Personalization affects user-system relationship by allowing a system to customize communication rules. Like a contextualized system, a personalized system is supposed to provide information to users in the ways that they prefer and should enhance both perceived understanding and motive fulfilment as long as the system is also interactive. Unlike task contexts, however, user preferences are subjective, and therefore people are aware of them and can make their own choices at any moment. Even if the information about user preferences is "accurately" inferred or elicited at a point of time, they may change later (Schneider and Barnes, 2003). Because people usually do not want others to impose personal decisions on them, a system of higher-level personalization is more likely to make users feel they are losing control. As a result, personalization as a means of information automation is generally not welcomed by users (Karat et al., 2003; Nunes and Kambil, 2001). These considerations lead to mixed effects of personalization, based on the condition that a system is interactive:

H3a: Personalization has a negative effect on sense of control.
H3b: Personalization has a positive effect on perceived understanding.
H3c: Personalization has a positive effect on motive fulfilment.

Finally, sense of control, perceived understanding and motive fulfilment lead to the formation of user readiness, which can be used to predict system choice (Sun, 2012). Hence, the below are hypothesized:

H4a: Sense of control has a positive effect on user readiness.
H4b: Perceived understanding has a positive effect on user readiness.
H4c: Motive fulfilment has a positive effect on user readiness.
H5: User readiness makes a difference in system choice.

4 METHODOLOGY

4.1 Experiment Design

To test the research framework, it is necessary to create experimental treatments that demonstrate to participants different levels interactivity, contextualization and personalization. Treatments should be as different as possible for the maximization of systematic variance and minimization of error variance (Kerlinger, 1986), and each system capability was arranged to have two levels: high (indicated by '1') or low (indicated by '0'). The binary specifications of three system capabilities result in eight possible combinations. For example, the treatment that is high on interactivity but low on contextualization and personalization is indicated by the node I1C0P0.

To answer the first research question whether interactivity is the necessary condition for users to be ready to interact with a system, subject responses can be compared between low-level interactivity and high-level interactivity. Neither treatment should be explicitly personalized or contextualized in order to filter out the noises from other system capabilities. Thus, the two relevant treatments are I0P0C0 and I1P0C0. If the result supports the necessity of interactivity to the formation of user readiness, the next step is to answer the second research question whether contextualization and personalization enhance or weaken user readiness for interactive systems. Because of the likely interplay between these two capabilities (Chen and Pu, 2014), a two-by-two factorial design is used to test both main and interaction effects, leading to four treatments: I1C0P0, I1C1P0, I1C0P1, and I1C1P1.

The author developed an experiment tool to expose participants to different designs on simulated smart phones, which naturally creates a ubiquitous environment for demonstrating system capabilities

(Ogara & Koh, 2014). As illustrated by the screen shots in Figure 3, the designs varied in interactivity, personalization and contextualization. The laboratory scenario was that the participants tried to find a nearby nightclub in a city to enjoy the music they like (e.g. rock, country and jazz etc.). The ubiquitous systems of different designs accessed the same database that contained the names, music types and locations of all the nightclubs in the area.

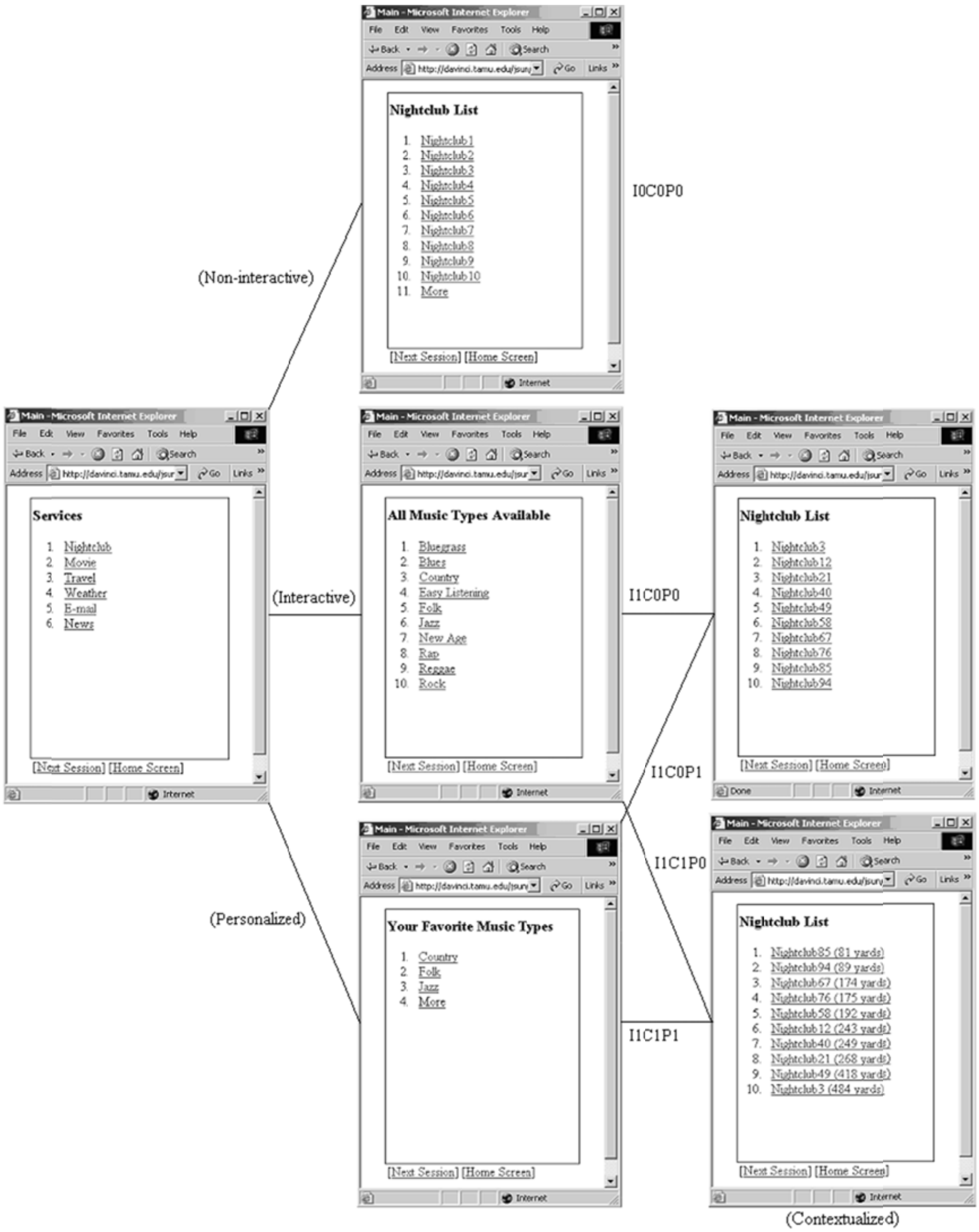


Figure 3. *Laboratory Setting and Procedures*

The implementation of five treatments is as follows: the system corresponding to the I0C0P0 treatment (not interactive, contextualized or personalized) lists all nightclubs in the city by alphabetic order; the system corresponding to the I1C0P0 treatment (interactive but not contextualized or personalized) allows a user to select a music type from a complete list first, and then gives relevant clubs in alphabetic order; the system corresponding to the I1C1P0 treatment (interactive and contextualized but not personalized) allows a user to select a music type from a complete list first, and then gives relevant clubs in order of distance from the user; the system corresponding to the I1C0P1 treatment (interactive and personalized but not contextualized) lets participants choose from a list of their favourite music types, and then gives relevant clubs in alphabetic order; and the system corresponding to the I1C1P1 treatment (interactive, contextualized and personalized) lets participants choose from a list of their preferred music types, and then lists the relevant nightclubs in proximity order.

At the beginning of a session, participants indicated their music preferences by selecting up to three of their favourite music types from 10 options. Then they used all five systems in a random order to complete the task. Before interacting with each system, a participant selected or was randomly assigned a location on the city map. Based on user input, a system generated a list of nightclubs and displayed them in hyperlinks. A participant clicked a link to view how far the place is and the type of music featured, and decided whether to confirm the selection or go back to the previous step(s) and search again. After a participant made a confirmation, a score was automatically calculated indicating his/her performance by taking into account how close the club was to the person, whether the club was of the person's favourite music type, and how quickly the person found the club information. After using each system, participants answered the questions of user readiness and system experiences.

A pilot study was conducted for manipulation checks. Forty-three students from an undergraduate class participated. They were asked to follow the experiment instructions and none of them indicated any difficulty in using the systems or answering questions. On average, the entire procedure took about 25 minutes. At the end, the participants were given a description of each treatment and asked the extent to which they agreed that its implementation was consistent with the description on seven-point Likert scales (from 1-strongly disagree to 7-strongly agree). As Table 1 shows, the 25th percentile is equal to or greater than the neutral point of four for all treatments, indicating the participants' perceptions of the treatments were in line with the intended operationalization.

	I0C0P0	I1C0P0	I1C1P0	I1C0P1	I1C0P1
Mean (Std. Dev.)	4.95(1.29)	4.91(0.87)	5.26(1.43)	4.98(1.14)	5.63(1.25)
25th Percentile	4.00	4.00	5.00	4.00	5.00
50th Percentile	5.00	5.00	5.00	5.00	6.00
75th Percentile	6.00	5.00	6.00	6.00	7.00

Table 1. Reliability Coefficients and Descriptive Statistics

4.2 Subjects

The target population for this study is people who use various information systems in their life, study and work. Because computer use is now a basic requirement on university campuses, the subject pool in this study comprised the college students who took an information systems literacy course from a southwest university in U.S.A. Participation was voluntary and subjects were given extra credit for agreeing to participate in the study. In all, there were 106 participants and they had a good mixture of academic backgrounds and computer skills. In the experiment of repeated-measure design, each of them answered the same set of questions for five treatments, resulting in a sample size of 530 at the within-subject level.

4.3 Measurement

The dependent variable, user readiness, was measured with the short version of information system interaction readiness instrument developed and validated to study user system choice behaviour (Sun and Poole, 2010). There were cognitive, affective and behavioural items that measured each of the three factors including input willingness, output receptivity and rule observance.

Sense of control was measured with three items adapted from Ajzen and Madden's (1986) Perceived Behavioural Control scale. Perceived understanding was adapted from Cahn and Shulman's (1984) Perceived Understanding Instrument, including two Likert items for Perceived Being Understood and Perceived Being Misunderstood, respectively, and one item asking how much a subject feels that a system generally understood him/her during the interaction. Motive fulfilment was measured objectively with the previously-mentioned performance score automatically calculated in terms of how quickly a participant found a nearby club that featured his/her favourite music types.

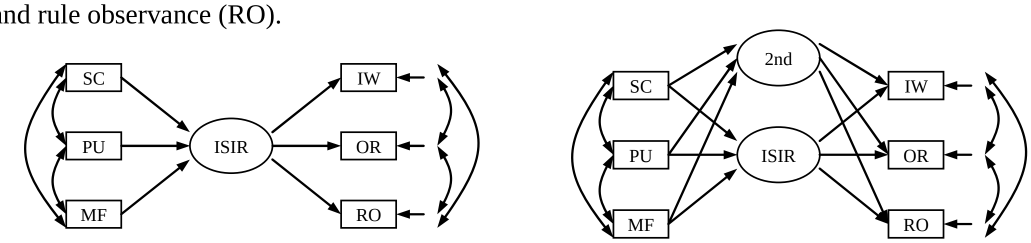
5 RESULTS

First, reliability coefficients and descriptive statistics were obtained for all the measures as shown in Table 2. The reliability of the measures was assessed by taking the average of coefficient alphas across the five treatments. All coefficient alphas were above 0.7, indicating the internal consistency of responses to the measures was acceptable. This justified the calculation of index score for each one-dimensional construct by taking the average of its item scores. The mean index scores showed that sense of control, perceived understanding, motive fulfilment and user readiness factors varied significantly across different treatments. On average, the scores for the I0C0P0 treatment (not interactive, contextualized or personalized) were the lowest, and the scores for the I1C1P1 treatment (interactive, contextualized and personalized) were the highest. This result indicated that the treatment manipulation had expected effects as interactivity, contextualization and personalization were supposed to enhance system experiences and user readiness in general.

	α	I0C0P0	I1C0P0	I1C1P0	I1C0P1	I1C1P1
Sense of Control	.79	2.38 (.77)	5.08 (.72)	6.07 (.67)	4.48 (.77)	6.05 (.69)
Perceived Understanding	.84	2.46 (.74)	4.40 (.91)	6.03 (.68)	5.18 (.73)	6.11 (.70)
Motive Fulfilment	N/A	2.00 (.68)	3.84 (.79)	6.15 (.68)	4.45 (.71)	6.70 (.42)
Input Willingness	.79	2.63 (.75)	4.58 (.83)	5.84 (.72)	4.72 (.72)	5.87 (.75)
Output Receptivity	.78	2.44 (.71)	4.57 (.81)	6.01 (.67)	4.84 (.68)	6.13 (.62)
Rule Observance	.78	2.31 (.73)	4.45 (.82)	5.88 (.70)	4.64 (.76)	5.91 (.75)

Table 2. Reliability Coefficients and Descriptive Statistics

To test the research hypotheses of how system capabilities influence user readiness through the mediation of relevant experiences, a two-step strategy was employed. The first step examines whether most of the variation in user readiness factors is explained by sense of control, perceived understanding and motive fulfilment. If the results support that they are indeed the major antecedents of user readiness, the next step will test the effects of system capabilities on these system experiences. The first-order multiple-indicators/multiple-causes (MIMIC) model in Figure 4 depicts statistically sense of control (SC), perceived understanding (PU) and motive fulfilment (MF) lead to the formation of user readiness (ISIR), which has three indicators: input willingness (IW), output receptivity (OR) and rule observance (RO).



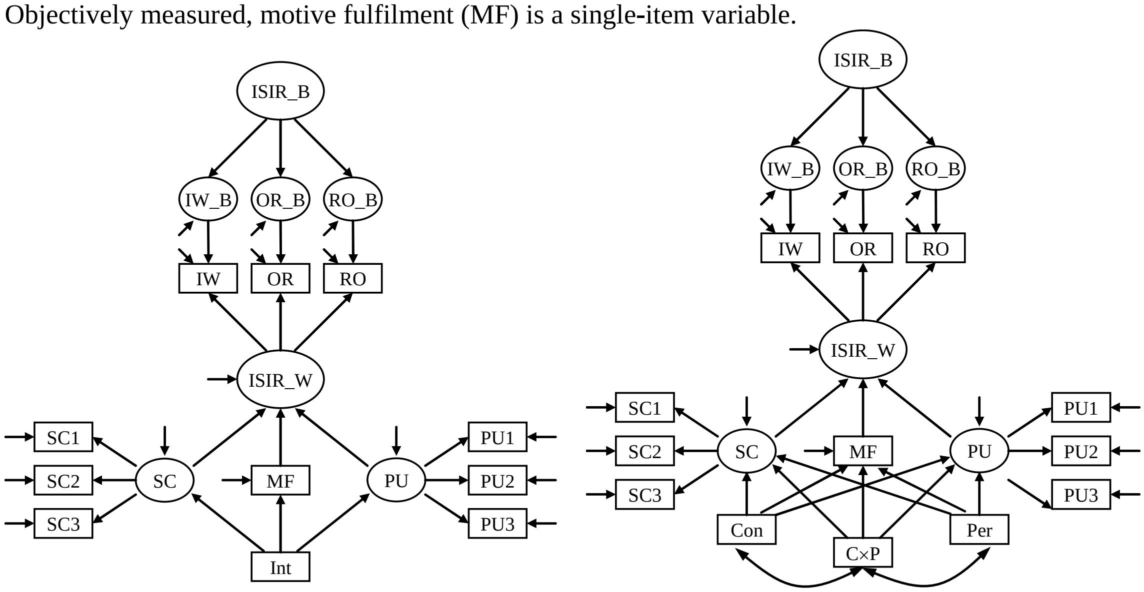
First-Order Model Second-Order Model

Figure 4. MIMIC Model of User Readiness

A multi-group analysis (N = 106) across five different treatments yielded an acceptable goodness-of-fit (χ^2/df = 1.74; RMSEA= .038; CFI = .992). The MIMIC model is equivalent to a first-order canonical correlation function, and its significance can be accurately tested with structural equation modeling (Fan, 1997). The chi-square difference test between the MIMIC model and the null model (in which the paths to and from the latent variable ISIR were constrained to be zeros) indicated that the first-order canonical correlation function was highly significant (Δdf = 25, $\Delta\chi^2$ = 475.59, p-value < 0.001). Also, the result of traditional canonical correlation analysis was obtained using SPSS: the canonical correlation coefficient was 0.95, and 86.7% of the variance of user readiness factors – IW, OR and RO – was explained by SC, PU and MF through the first-order canonical function. Because most shared variance between two sets of variables was explained, the second-order model in Figure 6 did not improve the model fit significantly (Δdf = 25, $\Delta\chi^2$ = 33.56, p-value = 0.12). These results suggest that sense of control, perceived understanding and motive fulfillment are the major antecedents of user readiness.

Then the hypothesized mediated relationships between system capabilities and user readiness were tested. Because the study adopted repeated-measure (orwithin-subject) design, the appropriate statistical method for hypothesis testing should account for the variances at both between-subject level and within-subject level in order to minimize the error variance. For the analysis involving such hierarchical structure as well as mediated relationships and latent constructs, the multi-level structural equation modelling (SEM) method is appropriate (Goldstein and McDonald, 1988).

Figure 5 shows the two structural models tested: one for testing the primary effects of interactivity (Int) and the other for testing the secondary effects of personalization (Per), contextualization (Con) and their interaction term (CxP). In these models, user readiness at the within-subject level (ISIR_W) were indicated by input willingness (IW), output receptivity (OR) and rule observance (RO), and their shared variances across different treatments were accounted by the latent indicators (IW_B, OR_B and RO_B) of user readiness at the between-subject level (ISIR_B). Both sense of control (SC) and perceived understanding (PU) had three indicators corresponding to their measurement items. Objectively measured, motive fulfilment (MF) is a single-item variable.



Model 1. Interactivity | Model 2. Contextualization and Personalization

Figure 5. Multi-level Structural Models

The multilevel structure models were simultaneously fit to the pooled within-subject and scaled between-subject correlation matrices obtained with Muthén’s (1989, 1994) maximum-likelihood (MUML) method. The fit indices (Model 1: χ^2/df = 1.417, RMSEA= .063, CFI = .992; Model 2: χ^2/df = 3.574; RMSEA= .090; CFI = .970) indicated that the goodness-of-fit was acceptable for both models. Parameter estimates were given in Table 3. Consistent with the previous canonical correlation analysis, sense of control (SC), perceived understanding (PU) and motive fulfillment (MF) had positive effects on user readiness at the within-subject level (ISIR_W) for both models. For the first model, interactivity had positive effects on SC, PU and MF, supporting hypotheses H1a-c. For the second model assuming the system is interactive, contextualization had positive effects on SC, PU and MF, which supported hypotheses H2a-c. Personalization, however, had positive effects on PU and MF but a negative effect on SC, which supported hypotheses H3a-c that personalization has mixed effects. In addition, the interaction term (CxP) had a positive effect on SC, a negative effect on PU, and non-significant effect on MF. Finally, SC, PU and MF had positive effects on ISIR_W for both models, supporting hypothesis H4a-c that these system experiences lead to the formation of user readiness.

Level	Variable	Path	Model 1	Model 2
Within	Readiness-Within (ISIR_W)	ISIR_W ---> IW	1.000 (.947)	1.000 (.914)
		ISIR_W ---> OR	1.086 (.979)	1.119 (.952)
		ISIR_W ---> RO	1.094 (.980)	1.105 (.939)
	Sense of Control (SC)	SC ---> SC1	1.000 (.950)	1.000 (.854)
		SC ---> SC2	.946 (.950)	1.183 (.906)
		SC ---> SC3	.903 (.966)	1.085 (.858)
	Perceived Understanding (PU)	PU ---> PU1	1.000 (.955)	1.000 (.902)
		PU ---> PU2	1.067 (.949)	.982 (.889)
		PU ---> PU3	.955 (.954)	.927 (.887)
	System Experiences	SC ---> ISIR_W (H4a)	.229 (.328)	.337 (.350)
		PU ---> ISIR_W (H4b)	.472 (.495)	.347 (.430)
		MF ---> ISIR_W (H4c)	.210 (.205)	.168 (.312)
	Interactivity (Int)	Int ---> SC (H1a)	2.841 (.953)	/
		Int ---> PU (H1b)	1.935 (.888)	/
		Int ---> MF (H1c)	1.846 (.911)	/
	Contextualization (Con)	Con ---> SC (H2a)	/	.914 (.637)
		Con ---> PU (H2b)	/	1.685 (.983)
		Con ---> MF (H2c)	/	2.301 (.898)
	Personalization (Per)	Per ---> SC (H3a)	/	-.548 (-.382)
		Per ---> PU (H3b)	/	.797 (.465)
		Per ---> MF (H3c)	/	.606 (.236)
	Contextualization x Personalization (CxP)	CxP ---> SC	/	.512 (.309)
		CxP ---> PU	/	-.733 (-.370)
		CxP ---> MF	/	-.049^{ns} (-.016)
Between	Readiness-Between (ISIR_B)	ISIR_B ---> IW_B	1.000 (.916)	1.000 (.790)
		ISIR_B ---> OR_B	1.668 (1.052)	.944 (.837)
		ISIR_B ---> RO_B	1.363 (.767)	1.174 (.916)

Table 3. Parameter Estimates for Structural Models (Note: Standard estimates were given in parentheses. All estimates except the one with the superscript of "ns" were significant at 0.001 level.)

SEM is able to test mediating effects in a straightforward way (Brown, 1997; Mackenzie, 2001). The direct paths from system capabilities to user readiness at the within-subject level (ISIR_W) were added to the structure models to test whether sense of control, perceived understanding and motive fulfilment were really the mediators. Consistent with the mediation hypothesis, all the direct paths added to the models were not significant (Int->ISIR: p-value = .662; Con->ISIR: p-value = .118; Per->ISIR: p-value = .745; CxP->ISIR: p-value =.397).

Finally, the relationship between user readiness and system choice was assessed. At the end of the experiment, each participant indicated which system he/she would like to use the most. Out of 106 participants, 66 (62.26%) and 37 (34.91%) chose the systems that correspond to their highest and second highest user readiness scores respectively. For the 37 participants, their highest and second highest scores were quite close as the average and standard deviation of score differences were 0.32 and 0.26 on a seven-level Likert scale. This provided supporting evidence for hypothesis H5.

6 CONCLUSION AND IMPLICATIONS

Based on Activity Theory, this study investigated how basic system capabilities including interactivity, personalization and contextualization affect user readiness. It conceptualized user-system interaction as a tool-mediated and context-embedded activity to transform raw data into meaningful information. Such a perspective provides the insights on the relationships among user, system and task. Based on the understanding of how system capabilities affect the relationships, relevant system experiences including sense of control, perceived understanding and motive fulfilment are identified. The research model hypothesized that system capabilities directly influence these system experiences that shape user readiness. The results suggest that interactivity is necessary for the formation of user readiness, and for interactive systems, contextualization enhances user readiness but personalization has mixed effects.

The main limitation of this study is related to the laboratory nature of the experiment used to test the research model. Compared with studies carried out in real world, laboratory studies are capable of giving the researcher a great deal of control. However, experiment treatments are typically simplified to enhance the effect size and they may not be very realistic. Unlike the dichotomous treatments (i.e. high vs. low) of interactivity, personalization and contextualization in this study, real systems vary in degrees regarding these capabilities. The use of student sample also places a limitation on the generalizability of results. Thus, the results obtained from laboratory studies involving student subjects are more appropriate for testing theoretical relationships than answering practical questions (e.g. evaluation of an actual system design) (Peterson, 2001). Future studies on the effects of system capabilities on user behaviour may require that field studies be conducted in actual task settings with real systems. One challenge in doing so is how to assess and control the differences of systems in terms of interactivity, personalization and contextualization. An evaluation scheme of system capabilities, therefore, needs to be developed before such studies can be conducted.

Despite the limitations, there are several theoretical and practical implications. First of all, the activity perspective of user-system interaction provides a means to understand how basic system capabilities influence user behaviour. Compared with the action-based frameworks (e.g. Technology Acceptance Model and Theory of Reasoned Action), this perspective does not treat a system as an object, but rather a complex tool comprising computer interfaces, communication rules and information technologies. These artefacts, implemented in different ways, endow information systems with different capabilities in terms of interactivity, personalization and contextualization. By incorporating these basic design features into analysis, the activity perspective help break the black-boxed and abstracted notation of information systems in previous research (Sun & Bhattacherjee, 2014).

In theorizing how system capabilities influence user attitudes, this study identifies relevant user experiences in interacting with various information systems as the mediators between two. Compared with simple causal theorizing, such a systematic deliberation on the multi-layer relationships taps the differences caused by system design on user behaviour. Thus, the model provides a meaningful explanation of why people prefer to interact with some systems rather than others due to the differences in their designs. Simple causal theorizing based on user summary evaluation of a system, on the other hand, may tap only secondary effects, rather than the direct effects caused by design features. For instance, in some studies users are asked to judge the action of using a system as generally favourable or unfavourable and report their attitudes accordingly. Though this type of causal relationships can be found to be highly statistically significant, it does not provide much insight into what specific experiences that users have in interacting with particular systems and how such experiences lead to their attitudes toward using the systems for similar purposes later.

For practitioners, the systematic examination of the relationship between system capabilities and user readiness may help them improve the design and implementation of systems in order to attract and retain users. First of all, the instrument and framework validated in this study provides the means to evaluate different system designs. Based on user responses, developers can assess the implementation of computer interfaces, communication rules and information technologies that lead to different levels of interactivity, personalization and contextualization. In particular, they can measure user readiness and relevant system experiences including sense of control, perceived understanding and motive fulfilment. If the score of user readiness is somewhat low due to the relatively negative responses on one or more of system experiences, developers can find out which aspects of design need to be improved. For example, if users perceive lack of understanding from a system, the design may be insufficient in personalization and the developers can improve relevant communication rules to provide more tailored information to user preferences.

The results suggest that system capabilities are not independent from each other in influencing user behaviour. Thus, system design needs to take the impacts of all of them into account and try to strike the balance. If a system in the above example is redesigned to be highly personalized for its users but they exhibit even lower readiness to interact with that system, the developers can check whether the design leads to lower sense of control. If so, the developers may revise the communication rules of the system to make them less obtrusive to the users, redesign the interface to give users more choices, and/or implement real-time information technologies to adapt to user current situations. After these improvements, the developers can further check whether they have expected effects on user behaviour by measuring user readiness and system experiences again. Through this evolutionary and user-centred approach, developers can make sure that the final design would lead to a system that people like to use.

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